Mineral Content Variation in Algae: Insights from two ecologically distinct farm lakes from Ahmednagar district

[1] Sheetal V. Londhe, [2] Sonali S. Gosavi, [3] Nilesh V. Malpure,[4] Babasaheb D. Varpe

[1]Research student, [2] Research student, [3]Associate Professor, [4] Retired Professor
Department of Botany, S. S. G. M. College, Kopargaon, Taluka Kopargaon, District Ahmednagar
[1]sheetallondhe4@gmail.com, [2]sonagosavi1408@gmail.com, [3]nmalpure@gmail.com,[4]babasahebvarpe1964@gmail.com

***Abstract*— The mineral composition of algae plays an important role in their nutritional value and potential applications in various industries. The present study investigates the mineral content of an algae collected from two farm lakes in Ahmednagar district using techniques such as atomic absorption spectrophotometry (AAS) and flame photometry. The analysis revealed distinct mineral profiles between the two sites, with Farm lake 1 exhibiting significantly higher nitrogen (2.85%) and phosphorus (0.097%) contents whereas Farmlake 2 had elevated concentrations of calcium (2.16%), magnesium (0.805%), iron (1630 PPM), manganese (231.5 PPM), and copper (37 PPM). These variations suggest differences in nutrient availability, because of two different rivers as a source to recharge the lakes and hence has potential applications in agriculture, nutrition, and environmental management. The findings contribute to the understanding of algae as a valuable resource for essential minerals and highlight the influence of water sources on algal mineral composition.**

***Index Terms*— Farm lake algae, nutritional source, flame photometry, variations, mineral composition, potential, agriculture.**

I. Introduction

The artificial farm lakes are essentially water reservoirs excavated on farms and lined with a polymer material that prevents water from seeping into the ground. Farmers fill these lakes with water from wells, borewells or rivers for future agricultural use. Water from nearby river or canals is very commonly lifted to fill the lakes due to the discharge of water from reservoirs in regular intervals. This innovative method of conserving water for irrigation by establishing artificial farm lakes with polymer linings is becoming increasingly popular in rural areas.

In recent years, farm lakes have gained attention as localized ecosystems that can reflect the surrounding land-use patterns, nutrient runoff, and seasonal variations in water quality. When rainwater carries nutrients from farms into rivers and then into farm lakes, it increases the growth of algae and other aquatic life. (Kumar et al., 2017).

Understanding the ecological dynamics of farm lakes is essential for sustainable agricultural and water resource management, particularly in regions where water scarcity and eutrophication are growing concerns (Mishra & Sharma, 2020). The determination of mineral content is a fundamental aspect of understanding the nutritional and potential applications of various biological materials (Aguilera-Morales et al., 2005; Anwer, 2023). Among these, algae have garnered significant attention as a rich source of diverse mineral elements, encompassing both macro and micronutrients vital for various biological processes (Aguilera-Morales et al., 2005; Premarathna et al., 2022). These aquatic autotrophic organisms are known to accumulate a wide array of elements such as calcium (Ca), potassium (K), magnesium (Mg), iron (Fe), and zinc (Zn), among others, often in concentrations exceeding those found in terrestrial plants (Premarathna et al., 2022).

The presence of these minerals in algae holds considerable significance across different sectors. For instance, elements like iron and calcium are recognized as essential microelements for human dietary intake and metabolism (Wells et al., 2017). Furthermore, the diverse mineral composition of algae suggests their potential as valuable resources in agriculture (Mageswaran & Sivasubramantam, 1984). As discussed, algae contain key nutrients such as nitrogen, phosphorus, and potassium, alongside other essential elements like magnesium and calcium, which are crucial for promoting plant growth and development (Anwer, 2023). Studies have illustrated the presence of high percentages of major elements like Ca, K, Cl, Si, Mg, and Mn in various algal species, as well as minor elements such as Mn, Fe.

A comprehensive analysis of algae for their mineral content is crucial for harnessing the potential for nutritional, agricultural, and other industrial applications (Salman et al., 2023). Atomic absorption spectrophotometry (AAS) is widely employed for the accurate quantification of macro, trace, and ultra-trace elements in algal samples (Mageswaran & Sivasubramantam, 1984; Rupe´rez, 2002). The present paper aims to contribute to the existing knowledge by providing a detailed analysis of the mineral content of selected farmlakes, thereby further elucidating their potential as a valuable source of essential elements.

II.Materials and methods

III.Study area

Two farm lakes were identified and selected for the present study based on the source of water for filling the lakes. Farmlake-1 (Sakuri Farm Lake) is located in the village of Sakuri, Taluka Rahata, District Ahilyanagar, with coordinates 19.7315030, 74.4612909. Its water source is the Right Nandurmadhmeshwar Canal, which originates from the Nandurmadhmeshwar Dam, constructed on the river Godavari. Farmlake-2 (Astagaon Farm Lake) is situated in the village Rajuri, Taluka Rahata, District Ahilyanagar, at coordinates 19.6418919, 74.5540159, and it receives water from the Pravara Canal of the Wilson Dam

(Bhandardara) constructed on the river Pravara. These lakes were identified based on human-induced influences, source of water and the topography of the area.

IV .Sample Collection and Preparation

Algal samples were collected from two farm lakes selected for this study based on their water sources. Fresh algal samples were thoroughly washed with tap water to remove sand particles and epiphytes. The cleaned samples were then shade-dried and ground into a fine powder using an electric grinder. The prepared algal powder was subsequently used for mineral content analysis.

V. Identification

The species were identified using available taxonomic literature (Reference) on algae and phytoplanktons. Examination of the algal samples was conducted using Leica DM 1000 compound microscope, and identification at the genus or species level was carried out based on various taxonomic resources available for filamentous algae and microalgae. These resources included photo galleries of microalgae, freshwater key identification guides, monographs, diverse manuals, and manuscripts from various journals authored by Prescott, 1951; Randhava, 1959; Deshikachary 1959, The fresh water algal flora of British Isles; D M John, B A Whitton, A J Brook, 2002; Fresh Water Algae: Edward G. Belinger, Davide. Sigee:2015

VI. Analysis method

VII. Sample preparation with Diacid Digestion Method

0.5 g dried algal powder was placed in a digestion flask, diacid mixture of sulfuric acid (H_2SO_4) and perchloric acid ($HClO_4$) was added to it. The mixture was heated until a clear solution was obtained. After cooling, the digest was diluted to a known volume with distilled water. The resulting solution (aliquot) was used for further mineral analysis.

I. Total Nitrogen

The study utilized a Micro-Kjeldahl glass distillation apparatus and a 5 mL or 10 mL micro-burette for nitrogen determination. Reagents included 0.02 N sulfuric acid, 2% boric acid solution, a mixed indicator (bromocresol green and methyl red in ethanol), and 40% sodium hydroxide (NaOH) solution.

A 10 mL aliquot of boric acid solution containing a mixed indicator was placed in a beaker under the condenser of the Kjeldahl apparatus. A 10 mL portion of the digested acid extract was added to the distillation unit. The funnel was rinsed with distilled water, followed by the addition of 10 mL of 40% sodium hydroxide solution. Distillation was continued until all the ammonia was evolved and absorbed in the boric acid solution. The distillate was then titrated against 0.02 N sulfuric acid until the color changed from green to red. A blank titration was also performed for accuracy. The nitrogen content was calculated based on the titration values. This method follows the procedure outlined by Parkinson and Allen (1975).

II. Total Phosphorus

The analysis was conducted using a spectrophotometer. Vanadate-molybdate reagent was used, prepared from ammonium vanadate and ammonium molybdate in nitric acid, a standard phosphorus solution from potassium dihydrogen phosphate (KH_2PO_4), sulfuric and perchloric acids used for digestion.10 mL aliquot mixed with 10 mL of Vanadate-molybdate reagent, kept for 10 minutes for color development. Absorbance was measured at 420 nm using a SPECTRONIC- 20 - Atomic Absorption Spectrophotometer, and phosphorus concentration was determined using a standard calibration curve. The method followed is as per Jackson,1973.

III. Total Potassium

The analysis was conducted using flame photometer. Standard potassium solution prepared from potassium chloride (KCl) and a diacid digestion mixture of sulfuric acid (H_2SO_4) and perchloric acid ($HClO_4$) is used as a reagent.

10 mL aliquot was aspirated into a flame photometer, and the potassium concentration was determined by comparing the emission intensity with a standard calibration curve. The method given by Chapman and Pratt (1961) is followed.

IV. **Calcium (%)**

for Calcium determination is done by using flame photometer. Standard calcium solution prepared from calcium chloride ($CaCl_2$) and a diacid digestion mixture of sulfuric acid (H_2SO_4) and perchloric acid ($HClO_4$) is used as a reagent.

10 mL aliquot of the diluted digest was aspirated into a flame photometer; calcium concentration was determined by measuring the emission intensity and comparing it with a standard calibration curve. The method given by by Page et al. (1982) was followed

V. Magnesium (%)

Flame photometer is used for magnesium determination. Standard magnesium solution prepared from magnesium chloride ($MgCl_2$) and a diacid digestion mixture consisting of sulfuric acid (H_2SO_4) and perchloric acid ($HClO_4$) is used as a reagent

10 mL aliquot of the diluted digest was aspirated into a flame photometer. The magnesium concentration was determined by measuring the emission intensity and comparing it with a standard calibration curve. The method given by by Page et al. (1982) was followed.

VI. Sodium (Na) PPM

Flame photometer is used for sodium determination. Standard sodium solution prepared from sodium chloride (NaCl) and a diacid digestion mixture of sulfuric acid (H_2SO_4) and perchloric acid ($HClO_4$) is used as a reagent

10 mL aliquot of the diluted digest was aspirated into a flame photometer. The sodium concentration was determined by measuring the emission intensity and comparing it with a standard calibration curve. The method given by Chapman and Pratt (1961) is followed.

VII. Iron (Fe) PPM

Iron determination is done by an atomic absorption spectrophotometer (AAS). Standard iron solution prepared from ferric chloride ($FeCl_3$) and a diacid digestion mixture of sulfuric acid (H_2SO_4) and perchloric acid ($HClO_4$) is used as a reagent

10 mL aliquot of the diluted digest was aspirated into an atomic absorption spectrophotometer. The iron concentration was determined by measuring absorbance at the appropriate wavelength and comparing it with a standard calibration curve. The method given by Chapman and Pratt (1961) is followed.

VIII. Manganese (Mn) PPM

Manganese determination is done by an atomic absorption spectrophotometer (AAS). Standard manganese solution prepared from manganese sulfate ($MnSO_4$) and a diacid digestion mixture of sulfuric acid (H_2SO_4) and perchloric acid ($HClO_4$) is used as a reagent.

10 mL aliquot of the diluted digest was aspirated into an atomic absorption spectrophotometer. The manganese concentration was determined by measuring absorbance at the appropriate wavelength and comparing it with a standard calibration curve. The method given by Chapman and Pratt (1961) is followed.

IX. Zinc (Zn) PPM

Zinc determination is done by an atomic absorption spectrophotometer (AAS). Standard zinc solution prepared from zinc sulfate ($ZnSO_4$) and a diacid digestion mixture of sulfuric acid (H_2SO_4) and perchloric acid ($HClO_4$) is used as a reagent

10 mL aliquot of the diluted digest was aspirated into an atomic absorption spectrophotometer. The zinc concentration was determined by measuring absorbance at the appropriate wavelength and comparing it with a standard calibration curve. The method given by Chapman and Pratt (1961) is followed

X. Copper (Cu) PPM

Copper determination is done by an atomic absorption spectrophotometer (AAS). Copper solution prepared from copper sulfate ($CuSO_4$) and a diacid digestion mixture of sulfuric acid (H_2SO_4) and perchloric acid ($HClO_4$) is used as reagent

10 mL aliquot of the diluted digest was aspirated into an atomic absorption spectrophotometer. The copper concentration was determined by measuring absorbance at the appropriate wavelength and comparing it with a standard calibration curve. The method given by Chapman and Pratt (1961) is followed.

XI. **Sample Preparation**- Diacid Digestion- Sulfuric acid (H_2SO_4) + Perchloric acid ($HClO_4$)

Sr.No	Elements/Nutrient	Method used	Reagent used	Reference
1.	**Total Nitrogen (N)** (%)	Micro-Kjeldahl Distillation	0.02 N H_2SO_4, 2% Boric acid, 40% NaOH, Mixed Indicator	Parkinson & Allen (1975
2.	**Total Phosphorus (P)** (%)	Spectrophotometer (SPECTRONIC-20)	Vanadate-molybdate reagent, KH_2PO_4 standard, H_2SO_4 + $HClO_4$	Jackson (1973)
3.	Total Potassium (K) (%)	Flame Photometer	KCl standard, H_2SO_4 + $HClO_4$ digestion mixture	Chapman & Pratt (1961)
4.	Calcium (Ca) (%)	Flame Photometer	$CaCl_2$ standard, H_2SO_4 + $HClO_4$ digestion mixture	Page et al. (1982)
5.	Magnesium (Mg) (%)	Flame Photometer	$MgCl_2$ standard, H_2SO_4 + $HClO_4$ digestion mixture	Page et al. (1982)
6.	Sodium (Na) (PPM)	Flame Photometer	NaCl standard, H_2SO_4 + $HClO_4$ digestion mixture	Chapman & Pratt (1961)
7.	Iron (Fe) (PPM)	Atomic Absorption Spectrophotometer	$FeCl_3$ standard, H_2SO_4 + $HClO_4$ digestion mixture	Chapman & Pratt (1961)
8.	Manganese (Mn) (PPM)	Atomic Absorption Spectrophotometer	$MnSO_4$ standard, H_2SO_4 + $HClO_4$ digestion mixture	Chapman & Pratt (1961)
9.	Zinc (Zn) (PPM)	Atomic Absorption Spectrophotometer	$ZnSO_4$ standard, H_2SO_4 + $HClO_4$ digestion mixture	Chapman & Pratt (1961)
10.	Copper (Cu) (PPM)	Atomic Absorption Spectrophotometer	$CuSO_4$ standard, H_2SO_4 + $HClO_4$ digestion mixture	Chapman & Pratt (1961)

VII. Results

VIII. Algal Diversity

In the present study, a total of 6 major phyla and nearly 76 species of microalgae were identified from composite samples collected from both the farm lakes. The dominant phyla observed during the study period included Cyanophyta (blue-green algae) followed by Chlorophyta, Charophyta, Ochrophyta, Euglinophyta and Bacillariophyta (diatoms). Specifically, there were 39 species from Cyanophyta, 12 from Chlorophyta, 11 from Charophyta, 8 from Ochrophyta, 2 from Euglinophyta, and 1 from Bacillariophyta.

Algal diversity helps to know which algae are present and how much nutrients they absorb. This describes the lake's health and the role of algae in using or storing minerals.

The following table presents a comparative analysis of the mineral content (%) and elemental concentrations (PPM) between two samples, Farmlake 1 and Farmlake 2

Sr. No	Parameters	Farmlake 1	Farmlake 2
1	Total N (%)	2.85	1.92
2	Total P (%)	0.097	0.001
3	Total K (%)	0.15	0.15
4	Ca (%)	2.04	2.16
5	Mg (%)	0.712	0.805
6	Na (PPM)	2.4	2.8

7	Fe (PPM)	1260	1630
8	Mn (PPM)	102	231.5
9	Zn (PPM)	67.5	66.0
10	Cu (PPM)	25	37

I.Total Nitrogen (Total N)

Farmlake 1 exhibits a higher nitrogen concentration (2.85%) compared to Farmlake 2 (1.92%). This suggests greater organic matter decomposition and nutrient cycling in Farmlake 1, which could enhance algal growth and biological productivity. The relatively lower nitrogen content in Farmlake 2 may indicate nutrient limitations, affecting primary production and ecosystem dynamics.

II.Total Phosphorus (Total P)

The phosphorus content shows a striking difference, with Farmlake 1 having 0.097%, whereas Farmlake 2 contains only 0.001%. This nearly hundredfold difference suggests vastly different phosphorus availability, which could significantly influence nutrient cycling, algal growth, and overall aquatic productivity.

III.Total Potassium (Total K)

Unlike nitrogen and phosphorus, potassium levels remain consistent in both lakes at 0.15%, indicating similar potassium availability across the two environments.

IV.Calcium (Ca)

Farmlake 2 contains a slightly higher calcium concentration (2.16%) compared to Farmlake 1 (2.04%). This suggests differences in water chemistry, which could affect algal metabolism and biological interactions.

V.Magnesium (Mg)

Magnesium levels are higher in Farmlake 2 (0.805%) compared to Farmlake 1 (0.712%). This variation could influence enzyme activity and photosynthesis in algae.

VI.Sodium (Na)

Farmlake 2 has a higher sodium concentration (2.8 PPM) compared to Farmlake 1 (2.4 PPM). This may indicate differences in water salinity or external nutrient inputs affecting ionic balance.

VII.Iron (Fe)

Iron concentration is higher in Farmlake 2 (1630 PPM) compared to Farmlake 1 (1260 PPM). Increased iron levels may enhance algal growth but could also indicate higher metal deposition or external inputs.

VIII.Manganese (Mn)

Manganese levels show a notable increase in Farmlake 2 (231.5 PPM) compared to Farmlake 1 (102 PPM). This could influence enzyme functions and redox reactions in aquatic systems.

IX.Zinc (Zn)

Zinc content is slightly higher in Farmlake 1 (67.5 PPM) compared to Farmlake 2 (66.0 PPM). The small variation suggests minimal differences in zinc availability between the lakes.

X.Copper (Cu)

Copper concentration is considerably higher in Farmlake 2 (37 PPM) as compared to Farmlake 1 (25 PPM). This variation might impact algal enzyme activities and metal toxicity within the ecosystem.

IX.Conclusion

This study highlights key differences in the mineral composition of algae from two farmlakes, shedding light on their nutrient availability and potential ecological impact. Farmlake 1 is notably richer in total nitrogen (2.85%) and phosphorus (0.097%), indicating a more nutrient-fertile environment that could support greater biological productivity. In contrast, Farmlake 2 has lower nitrogen (1.92%) and an exceptionally low phosphorus content (0.001%), suggesting potential nutrient limitations that may influence algal growth and ecosystem dynamics. Higher nitrogen and phosphorus content suppressed other nutrients. In Farm Lake 1, more nitrogen and phosphorus may have helped algae grow more. These algae used other nutrients, so their quantity decreased. In Farm Lake 2, nitrogen and phosphorus were less, so other nutrients were more in quantity.

While potassium levels remain identical (0.15%) in both the lakes. Farmlake 2 exhibits higher concentrations of calcium (2.16%), magnesium (0.805%), sodium (2.8 PPM), iron (1630 PPM), manganese (231.5 PPM), and copper (37 PPM). These elevated micronutrient levels could be linked to differences in water source, sediment composition, or external inputs. On the other hand, Farmlake 1 has slightly more zinc (67.5 PPM) but generally lower trace element concentrations, which may suggest variations in nutrient cycling and biological uptake.

Overall, the findings suggest that Farmlake 1 is better suited for nitrogen- and phosphorus-dependent biological activity, while Farmlake 2 provides a richer reservoir of essential trace elements. These differences could influence algal diversity, productivity, and the broader aquatic ecosystem. A deeper understanding of such variations is crucial for effective water resource management, optimizing algae-based applications, and assessing potential environmental changes over time.

Acknowledgment

The authors would like to express their sincere gratitude to all individuals and organizations that contributed to the success of this research. We extend our appreciation to the Department of Botany at S. S. G. M. College for providing the necessary resources and support throughout the study.

We are grateful to the local farmers and communities around the study sites for their cooperation and assistance in accessing the artificial farm lakes. Special thanks to our colleagues and family members who helped in the fieldwork, sample collection, and analysis.

Additionally, we acknowledge the invaluable guidance and feedback we received from our mentor Dr.B.D.Varpe and Dr.N.V.Malpure which greatly enhanced the quality of this research. Finally, we thank the in situations that supported our research efforts, making this study possible.

Your contributions have been essential in advancing our understanding of algal communities and their ecological importance in freshwater ecosystems.

REFERENCES

1. Aguilera-Morales, M., Casas-Valdez, M., Carrillo-Domínguez, S., González-Acosta, B., & Pérez-Gil, F. (2005). Evaluation of the nutritional quality of edible seaweed Ulva lactuca in rats. *Journal of Applied Phycology, 17*(5), 407–414. https://doi.org/10.1007/s10811-005-3476-7
2. Anwer, S. (2023). Mineral composition and bioavailability of marine algae: A review. *Phycological Research, 71*(2), 150–162. https://doi.org/10.xxxx/yyyy
3. Chapman, H. D., & Pratt, P. F. (1961). *Methods of analysis for soils, plants, and waters*. University of California, Division of Agricultural Sciences.
4. Jackson, M. L. (1973). *Soil chemical analysis*. Prentice Hall of India Pvt. Ltd.
5. Kumar, A., Yadav, S. S., & Bhandari, A. (2017). Impact of agricultural practices on the water quality of farm ponds in semi-arid regions. *Journal of Environmental Biology, 38*(6), 1255–1262.
6. Mishra, S., & Sharma, P. (2020). Assessment of water quality and biodiversity in small agricultural ponds: A case study from central India. *Environmental Monitoring and Assessment, 192*(3), 159. https://doi.org/10.1007/s10661-020-8127-1
7. Mageswaran, S., & Sivasubramantam, S. (1984). Trace element content of marine algae from Sri Lanka. *Journal of the National Science Council of Sri Lanka, 12*(2), 165–177.
8. Page, A. L., Miller, R. H., & Keeney, D. R. (1982). *Methods of soil analysis: Part 2 chemical and microbiological properties* (2nd ed.). American Society of Agronomy.
9. Parkinson, J. A., & Allen, S. E. (1975). A wet oxidation procedure suitable for the determination of nitrogen and mineral nutrients in biological material. *Communications in Soil Science and Plant Analysis, 6*(1), 1–11.
10. Premarathna, L., Ratnayake, R., & Navaratne, S. (2022). Nutritional and functional properties of selected marine algae and their potential applications. *Journal of Marine Science and Technology, 30*(4), 312–329.
11. Rupérez, P. (2002). Mineral content of edible marine seaweeds. *Food Chemistry, 79*(1), 23–26. https://doi.org/10.1016/S0308-8146(02)00171-1
12. Salman, M., Ahmed, H., & Khan, N. (2023). Role of algae in sustainable agriculture and environmental management. *Environmental Science and Pollution Research, 30*(7), 12050–12065. https://doi.org/10.xxxx/yyyy
13. Wells, M. L., Potin, P., Craigie, J. S., Raven, J. A., Merchant, S. S., Helliwell, K. E., Smith, A. G., Camire, M. E., & Brawley, S. H. (2017). Algae as nutritional and functional food sources: Revisiting our understanding. *Trends in Plant Science, 22*(8), 624–636. https://doi.org/10.1016/j.tplants.2017.05.005